

AMENDMENTS TO THE CLAIMS

Claims 1-82 were originally filed.

Claims 31-35 and 47-53 are canceled.

Accordingly, claims 1-30, 36-46, and 54-82 are pending.

1. (Original) A method comprising:

transforming frames in a video sequence using a wavelet transform and motion information between frames to produce multiple sub-bands of coefficients; and

coding the coefficients of each sub-band independently.

2. (Original) A method as recited in claim 1, wherein the wavelet transform comprises a shape-adaptive discrete wavelet transform.

3. (Original) A method as recited in claim 1, wherein the transforming comprises performing a temporal 1-D wavelet transform along motion trajectories in a temporal direction.

4. (Original) A method as recited in claim 1, wherein the transforming comprises:

performing a temporal wavelet transform on corresponding pixels in a video object along motion trajectories in a temporal direction to produce frames of temporal wavelet coefficients; and

performing a spatial wavelet transform on the frames of the temporal wavelet coefficients to produce multiple sub-bands of wavelet coefficients.

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2 **5. (Original)** A method as recited in claim 1, wherein the coding
3 produces multiple bitstreams, one for each sub-band, and further comprising
4 forming a bitstream from the multiple bitstreams.

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6 **6. (Original)** A method as recited in claim 1, wherein the coding
7 comprises transposing selected sub-bands.

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9 **7. (Original)** A method as recited in claim 1, wherein the coding
10 comprises coding the coefficients of each sub-band bit-plane by bit-plane using
11 different coding primitives.

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13 **8. (Original)** A method as recited in claim 7, wherein the coding
14 primitives comprise:

15 zero coding to code new information about a coefficient that is not yet
16 significant in a previous bit-plane; and

17 sign coding to code a sign of the coefficient once the coefficient is deemed
18 significant.

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20 **9. (Original)** A method as recited in claim 7, wherein the coding
21 primitives comprise:

22 zero coding to code new information about a coefficient that is not yet
23 significant in a previous bit-plane;

24 sign coding to code a sign of the coefficient once the coefficient is deemed
25 significant; and

1 magnitude refinement to code new information of a coefficient that has
2 already become significant in the previous bit-plane.

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4 10. (Original) A method as recited in claim 1, wherein the coding
5 comprises assigning contexts to the coefficients of each sub-band based on
6 numbers of significant neighboring samples.

7
8 11. (Original) A method as recited in claim 10, wherein the sub-bands
9 include an LLL (low-low-low) sub-band and an LLH (low-low-high) sub-band
10 and the contexts are assigned as follows:

11

LLL and LLH Sub-bands				
h	v	a	d	Context
2	x	x	x	0
1	≥ 1	x	x	0
1	0	≥ 1	x	1
1	0	0	x	2
0	2	0	x	3
0	1	0	x	4
0	0	≥ 1	x	5
0	0	0	3	6
0	0	0	2	7
0	0	0	1	8
0	0	0	0	9

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20 where "h" represents a number of immediate horizontal neighbors that are
21 significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors
22 that are significant and $0 < v < 2$, "a" represents a number of immediate temporal
23 neighbors that are significant and $0 < a < 2$, and "d" represents a number of
24 immediate diagonal neighbors that are significant and $0 < d < 12$.
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12. (Original) A method as recited in claim 10, wherein the sub-bands include an LHH (low-high-high) sub-band and the contexts are assigned as follows:

LHH Sub-band			
h	v+a	d	Context
2	x	x	0
1	≥ 3	x	0
1	≥ 1	≥ 4	1
1	≥ 1	x	2
1	0	≥ 4	3
1	0	x	4
0	≥ 3	x	5
0	≥ 1	≥ 4	6
0	≥ 1	x	7
0	0	≥ 4	8
0	0	x	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

13. (Original) A method as recited in claim 10, wherein the sub-bands include an HHH (high-high-high) sub-band and the contexts are assigned as follows:

d	h+v+a	Context
≥ 6	x	0
≥ 4	≥ 3	1
≥ 4	x	2
≥ 2	≥ 4	3
≥ 2	≥ 2	4
≥ 2	x	5
≥ 0	≥ 4	6
≥ 0	≥ 2	7
≥ 0	1	8
≥ 0	0	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

14. (Original) A method as recited in claim 1, further comprising truncating a number of bits in each bit-plane according to rate-distortion curves.

15. (Original) A method as recited in claim 1, further comprising estimating motion trajectories of pixels in a video object from frame to frame in the video sequence and said transforming is performed on corresponding pixels along the motion trajectories.

16. (Original) A computer-readable medium comprising computer-executable instructions that, when executed by one or more processors, perform the method as recited in claim 1.

17. (Original) A method comprising:
 estimating motion trajectories of pixels in a video object from frame to frame in a video sequence;
 performing a temporal wavelet transform on the corresponding pixels along the motion trajectories in a temporal direction to produce frames of temporal wavelet coefficients;
 performing a spatial wavelet transform on the frames of the temporal wavelet coefficients to produce multiple sub-bands of wavelet coefficients; and
 coding each sub-band of wavelet coefficients independently.

18. (Original) A method as recited in claim 17, wherein the estimating comprises matching corresponding pixels in the video object from frame to frame in the video sequence.

1 **19. (Original)** A method as recited in claim 17, wherein the temporal
2 and spatial wavelet transforms comprise a shape-adaptive discrete wavelet
3 transform.

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5 **20. (Original)** A method as recited in claim 17, wherein the performing
6 a temporal wavelet transform comprises:

7 forming a pixel array containing pixels that continue from frame to frame in
8 the video sequence;

9 examining a pixel in a frame to determine whether the pixel is a terminating
10 pixel that does not continue to a next frame;

11 if the pixel is a terminating pixel, terminating the pixel array; and

12 if the pixel is not a terminating pixel, adding the pixel to the pixel array.

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14 **21. (Original)** A method as recited in claim 20, further comprising
15 transforming the pixels arrays to produce the frames of temporal wavelet
16 coefficients.

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18 **22. (Original)** A method as recited in claim 17, wherein the coding
19 comprises transposing selected sub-bands to reduce a number of sub-bands to be
20 coded.

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22 **23. (Original)** A method as recited in claim 17, wherein the coding
23 comprises:

24 coding the wavelet coefficients in bit-planes; and

25 allocating bits for the bit-planes according to a rate-distortion optimization.

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2 **24. (Original)** A method as recited in claim 17, further comprising
3 truncating bits allocated to a bit-plane at a point on a rate-distortion curve that
4 approximates a convex hull.
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6 **25. (Original)** A method as recited in claim 17, wherein the coding
7 comprises coding the wavelet coefficients of each sub-band bit-plane by bit-plane
8 using different coding primitives.
9

10 **26. (Original)** A method as recited in claim 25, wherein the coding
11 primitives comprise:

12 zero coding to code new information about a wavelet coefficient that is not
13 yet significant in a previous bit-plane; and

14 sign coding to code a sign of the wavelet coefficient once the wavelet
15 coefficient is deemed significant.
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17 **27. (Original)** A method as recited in claim 25, wherein the coding
18 primitives comprise:

19 zero coding to code new information about a wavelet coefficient that is not
20 yet significant in a previous bit-plane;

21 sign coding to code a sign of the wavelet coefficient once the wavelet
22 coefficient is deemed significant; and

23 magnitude refinement to code new information of a wavelet coefficient that
24 has already become significant in the previous bit-plane.
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1 **28. (Original)** A method as recited in claim 17, wherein the coding
2 produces multiple bitstreams for corresponding sub-bands of wavelet coefficients
3 and further comprising constructing a multi-layer bitstream from the multiple
4 bitstreams.

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6 **29. (Original)** A method as recited in claim 17, wherein the coding
7 comprises assigning contexts to the wavelet coefficients of each sub-band based
8 on numbers of significant neighboring samples.

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10 **30. (Original)** A computer-readable medium comprising computer-
11 executable instructions that, when executed by one or more processors, perform
12 the method as recited in claim 17.

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14 **31. (Cancelled)**

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16 **32. (Cancelled)**

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18 **33. (Cancelled)**

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20 **34. (Cancelled)**

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22 **35. (Cancelled)**
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1 **36. (Original)** A method comprising:
2 coding sub-bands of coefficients produced from transforming video frames
3 in an independent manner such that one sub-band of coefficients is coded
4 independently of another sub-band of coefficients; and
5 constructing a bitstream from the independently coded sub-bands.

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7 **37. (Original)** A method as recited in claim 36, wherein the coding
8 comprises transposing selected sub-bands prior to said coding.

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10 **38. (Original)** A method as recited in claim 36, wherein the coding
11 comprises coding the coefficients of each sub-band bit-plane by bit-plane using
12 different coding primitives.

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14 **39. (Original)** A method as recited in claim 38, wherein the coding
15 primitives comprise:

16 zero coding to code new information about a coefficient that is not yet
17 significant in a previous bit-plane; and

18 sign coding to code a sign of the coefficient once the coefficient is deemed
19 significant.

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21 **40. (Original)** A method as recited in claim 38, wherein the coding
22 primitives comprise:

23 zero coding to code new information about a coefficient that is not yet
24 significant in a previous bit-plane;

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sign coding to code a sign of the coefficient once the coefficient is deemed significant; and

magnitude refinement to code new information of a coefficient that has already become significant in the previous bit-plane.

41. (Original) A method as recited in claim 36, wherein the coding comprises assigning contexts to the coefficients of each sub-band based on numbers of significant neighboring samples.

42. (Original) A method as recited in claim 41, wherein the sub-bands include an LLL (low-low-low) sub-band and an LLH (low-low-high) sub-band and the contexts are assigned as follows:

LLL and LLH Sub-bands				
h	v	a	d	Context
2	x	x	x	0
1	≥ 1	x	x	0
1	0	≥ 1	x	1
1	0	0	x	2
0	2	0	x	3
0	1	0	x	4
0	0	≥ 1	x	5
0	0	0	3	6
0	0	0	2	7
0	0	0	1	8
0	0	0	0	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal

neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

43. (Original) A method as recited in claim 41, wherein the sub-bands include an LHH (low-high-high) sub-band and the contexts are assigned as follows:

LHH Sub-band			
h	v+a	d	Context
2	x	x	0
1	≥ 3	x	0
1	≥ 1	≥ 4	1
1	≥ 1	x	2
1	0	≥ 4	3
1	0	x	4
0	≥ 3	x	5
0	≥ 1	≥ 4	6
0	≥ 1	x	7
0	0	≥ 4	8
0	0	x	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

44. (Original) A method as recited in claim 41, wherein the sub-bands include an HHH (high-high-high) sub-band and the contexts are assigned as follows:

d	h+v+a	Context
≥ 6	x	0
≥ 4	≥ 3	1
≥ 4	x	2
≥ 2	≥ 4	3
≥ 2	≥ 2	4
≥ 2	x	5
≥ 0	≥ 4	6
≥ 0	≥ 2	7
≥ 0	1	8
≥ 0	0	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

45. (Original) A method as recited in claim 36, wherein the constructing comprises forming multiple bit-planes and truncating a number of bits in each bit-plane according to a rate-distortion curve.

1 **46. (Original)** A computer-readable medium comprising computer-
2 executable instructions that, when executed by one or more processors, perform
3 the method as recited in claim 36.

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5 **47. (Cancelled)**

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7 **48. (Cancelled)**

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9 **49. (Cancelled)**

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11 **50. (Cancelled)**

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13 **51. (Cancelled)**

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15 **52. (Cancelled)**

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17 **53. (Cancelled)**

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19 **54. (Original)** A video encoder comprising:
20 a wavelet transformer to transform frames in a video sequence into multiple
21 sub-bands of coefficients, the wavelet transform using motion information of
22 video objects in the frames; and
23 a coder to code the coefficients of each sub-band independently.
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1 **55. (Original)** A video encoder as recited in claim 54, wherein the
2 wavelet transformer applies a spatial-adaptive discrete wavelet transform to the
3 frames.

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5 **56. (Original)** A video encoder as recited in claim 54, wherein the
6 wavelet transformer applies a temporal wavelet transform on pixels in the frames
7 taken along motion trajectories in a temporal direction from frame to frame.

8
9 **57. (Original)** A video encoder as recited in claim 54, wherein the
10 wavelet transformer comprises a 3-D wavelet transformer that applies:

11 (1) a temporal 1-D wavelet transform on corresponding pixels in
12 consecutive frames along motion trajectories in a temporal direction to produce
13 temporal wavelet coefficients; and

14 (2) a spatial 2-D wavelet transform on the temporal wavelet coefficients.

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16 **58. (Original)** A video encoder as recited in claim 54, wherein the
17 wavelet transformer estimates motion trajectories of pixels in a video object from
18 frame to frame in the video sequence and initially transforms corresponding pixels
19 along the motion trajectories in the temporal direction.

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21 **59. (Original)** A video encoder as recited in claim 54, wherein the
22 coder codes transposes selected sub-bands to produced reduced set of sub-bands.
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60. (Original) A video encoder as recited in claim 54, wherein the coder codes the coefficients of each sub-band into bit-planes using different coding primitives.

61. (Original) A video encoder as recited in claim 54, wherein the coder comprises a context-based arithmetic coder to assign contexts to the coefficients of each sub-band based on different coding primitives.

62. (Original) A video encoder as recited in claim 61, wherein the sub-bands include an LLL (low-low-low) sub-band and an LLH (low-low-high) sub-band and the coder employs a zero coding primitive to code new information about a coefficient that is not yet significant in a previous bit-plane by assigning the contexts as follows:

LLL and LLH Sub-bands				
h	v	a	d	Context
2	x	x	x	0
1	≥ 1	x	x	0
1	0	≥ 1	x	1
1	0	0	x	2
0	2	0	x	3
0	1	0	x	4
0	0	≥ 1	x	5
0	0	0	3	6
0	0	0	2	7
0	0	0	1	8
0	0	0	0	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors

that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

63. (Original) A video encoder as recited in claim 61, wherein the sub-bands include an LHH (low-high-high) sub-band and the coder employs a zero coding primitive to code new information about a coefficient that is not yet significant in a previous bit-plane by assigning the contexts as follows:

LHH Sub-band			
h	v+a	d	Context
2	x	x	0
1	≥ 3	x	0
1	≥ 1	≥ 4	1
1	≥ 1	x	2
1	0	≥ 4	3
1	0	x	4
0	≥ 3	x	5
0	≥ 1	≥ 4	6
0	≥ 1	x	7
0	0	≥ 4	8
0	0	x	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

64. (Original) A video encoder as recited in claim 61, wherein the sub-bands include an HHH (high-high-high) sub-band and the coder employs a zero coding primitive to code new information about a coefficient that is not yet significant in a previous bit-plane by assigning the contexts as follows:

d	h+v+a	Context
≥ 6	x	0
≥ 4	≥ 3	1
≥ 4	x	2
≥ 2	≥ 4	3
≥ 2	≥ 2	4
≥ 2	x	5
≥ 0	≥ 4	6
≥ 0	≥ 2	7
≥ 0	1	8
≥ 0	0	9

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and "d" represents a number of immediate diagonal neighbors that are significant and $0 < d < 12$.

65. (Original) A video encoder as recited in claim 61, wherein the coder employs a sign coding primitive to code a sign of the coefficient once the coefficient is deemed significant by assigning the contexts as follows:

h=-1				H=0			
v	a	\hat{x}	Context	v	a	\hat{x}	Context
-1	-1	0	0	-1	-1	0	9
-1	0	0	1	-1	0	0	10
-1	1	0	2	-1	1	0	11
0	-1	0	3	0	-1	0	12
0	0	0	4	0	0	0	13
0	1	0	5	0	1	1	12
1	-1	0	6	1	-1	1	11
1	0	0	7	1	0	1	10
1	1	0	8	1	1	1	9

h=1			
v	a	\hat{x}	Context
-1	-1	1	8
-1	0	1	7
-1	1	1	6
0	-1	1	5
0	0	1	4
0	1	1	3
1	-1	1	2
1	0	1	1
1	1	1	0

where "h" represents a number of immediate horizontal neighbors that are significant and $0 < h < 2$, "v" represents a number of immediate vertical neighbors that are significant and $0 < v < 2$, "a" represents a number of immediate temporal neighbors that are significant and $0 < a < 2$, and \hat{x} is a sign symbol prediction in a given context.

1 **66. (Original)** A video encoder as recited in claim 54, wherein the
2 coder truncates a number of coding bits according to rate-distortion curves.

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4 **67. (Original)** An operating system embodied on a computer-readable
5 medium comprising a video encoder as recited in claim 54.

6
7 **68. (Original)** A video encoder comprising:
8 means for estimating motion trajectories of pixels in a video object from
9 frame to frame in a video sequence;
10 means for performing a temporal wavelet transform on the corresponding
11 pixels along the motion trajectories in a temporal direction to produce frames of
12 temporal wavelet coefficients;
13 means for performing a spatial wavelet transform on the frames of the
14 temporal wavelet coefficients to produce multiple sub-bands of wavelet
15 coefficients; and
16 means for coding each sub-band of wavelet coefficients independently.

17
18 **69. (Original)** A video encoder as recited in claim 68, wherein the
19 estimating means comprises means for matching corresponding pixels in the video
20 object from frame to frame in the video sequence.

21
22 **70. (Original)** A video encoder as recited in claim 68, wherein the
23 temporal and spatial wavelet transforms comprise a shape-adaptive discrete
24 wavelet transform.
25

1 **71. (Original)** A video encoder as recited in claim 68, wherein the
2 means for performing a temporal wavelet transform comprises:

3 means for forming a pixel array containing pixels that continue from frame
4 to frame in the video sequence;

5 means for examining a pixel in a frame to determine whether the pixel is a
6 terminating pixel that does not continue to a next frame;

7 if the pixel is a terminating pixel, means for terminating the pixel array; and

8 if the pixel is not a terminating pixel, means for adding the pixel to the
9 pixel array.

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11 **72. (Original)** A video encoder as recited in claim 68, wherein the
12 coding means comprises means for transposing selected sub-bands to reduce a
13 number of sub-bands to be coded.

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15 **73. (Original)** A video encoder as recited in claim 68, wherein the
16 coding means comprises:

17 means for coding the wavelet coefficients in bit-planes; and

18 means for allocating bits for the bit-planes according to a rate-distortion
19 optimization.

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21 **74. (Original)** A video encoder as recited in claim 68, further
22 comprising means for truncating bits allocated to a bit-plane at a point on a rate-
23 distortion curve that approximates a convex hull.

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1 **75. (Original)** A video encoder as recited in claim 68, wherein the
2 coding means comprises means for coding the wavelet coefficients of each sub-
3 band bit-plane by bit-plane using different coding primitives.

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5 **76. (Original)** A video encoder as recited in claim 68, wherein the
6 coding means produces multiple bitstreams for corresponding sub-bands of
7 wavelet coefficients and further comprising means for constructing a multi-layer
8 bitstream from the multiple bitstreams.

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10 **77. (Original)** A video encoder as recited in claim 68, wherein the
11 coding means comprises means for assigning contexts to the wavelet coefficients
12 of each sub-band based on numbers of significant neighboring samples.

13
14 **78. (Original)** A computer-readable medium comprising computer-
15 executable instructions that, when executed on a processor, direct a device to:
16 code sub-bands of coefficients produced from transforming video frames in
17 an independent manner such that one sub-band of coefficients is coded
18 independently of another sub-band of coefficients; and
19 construct a bitstream from the independently coded sub-bands.

20
21 **79. (Original)** A computer-readable medium as recited in claim 78,
22 further comprising computer-executable instructions that, when executed on a
23 processor, direct a device to transpose selected sub-bands prior to said coding.

1 **80. (Original)** A computer-readable medium as recited in claim 78,
2 further comprising computer-executable instructions that, when executed on a
3 processor, direct a device to code the coefficients of each sub-band bit-plane by
4 bit-plane using different coding primitives.

5
6 **81. (Original)** A computer-readable medium as recited in claim 78,
7 further comprising computer-executable instructions that, when executed on a
8 processor, direct a device to assign contexts to the coefficients of each sub-band
9 based on numbers of significant neighboring samples.

10
11 **82. (Original)** A computer-readable medium embodying an encoded
12 video signal constructed as a result of a process comprising:

13 transforming frames in a video sequence using a wavelet transform to
14 produce multiple sub-bands of coefficients;

15 coding the coefficients of each sub-band independently to produce multiple
16 bitstreams; and

17 forming a bitstream from the multiple bitstreams.
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